

$\Delta(1620)$ S_{31} $I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$ Status: ***

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1980 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

 $\Delta(1620)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1600 to 1660 (\approx 1630) OUR ESTIMATE			
1615.2 \pm 0.4	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1672 \pm 7	MANLEY 92	IPWA	$\pi N \rightarrow \pi N & N\pi\pi$
1620 \pm 20	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
1610 \pm 7	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1614.1 \pm 1.1	ARNDT 04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1612 \pm 2	PENNER 02c	DPWA	Multichannel
1617 \pm 15	VRANA 00	DPWA	Multichannel
1672 \pm 5	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
1617	ARNDT 95	DPWA	$\pi N \rightarrow N\pi$
1669	LI 93	IPWA	$\gamma N \rightarrow \pi N$
1620	BARNHAM 80	IPWA	$\pi N \rightarrow N\pi\pi$
1712.8 \pm 6.0	¹ CHEW 80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
1786.7 \pm 2.0	¹ CHEW 80	BPWA	$\pi^+ p \rightarrow \pi^+ p$
1657	CRAWFORD 80	DPWA	$\gamma N \rightarrow \pi N$
1580	² LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$
1600	³ LONGACRE 75	IPWA	$\pi N \rightarrow N\pi\pi$

 $\Delta(1620)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
135 to 150 (\approx 145) OUR ESTIMATE			
146.9 \pm 1.9	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
154 \pm 37	MANLEY 92	IPWA	$\pi N \rightarrow \pi N & N\pi\pi$
140 \pm 20	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
139 \pm 18	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
141.0 \pm 6.0	ARNDT 04	DPWA	$\pi N \rightarrow \pi N, \eta N$
202 \pm 7	PENNER 02c	DPWA	Multichannel
143 \pm 42	VRANA 00	DPWA	Multichannel
147 \pm 8	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
108	ARNDT 95	DPWA	$\pi N \rightarrow N\pi$
184	LI 93	IPWA	$\gamma N \rightarrow \pi N$
120	BARNHAM 80	IPWA	$\pi N \rightarrow N\pi\pi$

228.3±18.0	¹ CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$ (lower mass)
30.0± 6.4	¹ CHEW	80	BPWA	$\pi^+ p \rightarrow \pi^+ p$ (higher mass)
161	CRAWFORD	80	DPWA	$\gamma N \rightarrow \pi N$
120	² LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$
150	³ LONGACRE	75	IPWA	$\pi N \rightarrow N\pi\pi$

$\Delta(1620)$ POLE POSITION

REAL PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1590 to 1610 (≈ 1600) OUR ESTIMATE			
1595	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1608	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1600±15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1594	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1607	VRANA	00	DPWA Multichannel
1585	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1587	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
1583 or 1583	⁵ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
1575 or 1572	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

-2×IMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
115 to 120 (≈ 118) OUR ESTIMATE			
135	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
116	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
120±20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
118	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
148	VRANA	00	DPWA Multichannel
104	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
120	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90
143 or 149	⁵ LONGACRE	78	IPWA $\pi N \rightarrow N\pi\pi$
119 or 128	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$

$\Delta(1620)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
15	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
19	HOEHLER	93	SPED $\pi N \rightarrow \pi N$
15±2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
17	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
14	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
15	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90

PHASE θ

VALUE (°)	DOCUMENT ID	TECN	COMMENT
- 92	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
- 95	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$
-110±20	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-104	ARNDT 04	DPWA	$\pi N \rightarrow \pi N, \eta N$
-121	ARNDT 95	DPWA	$\pi N \rightarrow N\pi$
-125	ARNDT 91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90

 $\Delta(1620)$ DECAY MODES

The following branching fractions are our estimates, not fits or averages.

Mode	Fraction (Γ_i/Γ)
$\Gamma_1 N\pi$	20–30 %
$\Gamma_2 N\pi\pi$	70–80 %
$\Gamma_3 \Delta\pi$	30–60 %
$\Gamma_4 \Delta(1232)\pi, D\text{-wave}$	
$\Gamma_5 N\rho$	7–25 %
$\Gamma_6 N\rho, S=1/2, S\text{-wave}$	
$\Gamma_7 N\rho, S=3/2, D\text{-wave}$	
$\Gamma_8 N(1440)\pi$	
$\Gamma_9 N\gamma$	0.004–0.044 %
$\Gamma_{10} N\gamma, \text{ helicity}=1/2$	0.004–0.044 %

 $\Delta(1620)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$	Γ_1/Γ
0.2 to 0.3 OUR ESTIMATE	
• • • We do not use the following data for averages, fits, limits, etc. • • •	
0.315±0.001	ARNDT 06 DPWA $\pi N \rightarrow \pi N, \eta N$
0.09 ± 0.02	MANLEY 92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$
0.25 ± 0.03	CUTKOSKY 80 IPWA $\pi N \rightarrow \pi N$
0.35 ± 0.06	HOEHLER 79 IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •	
0.310±0.004	ARNDT 04 DPWA $\pi N \rightarrow \pi N, \eta N$
0.34 ± 0.01	PENNER 02C DPWA Multichannel
0.45 ± 0.05	VRANA 00 DPWA Multichannel
0.29	ARNDT 95 DPWA $\pi N \rightarrow N\pi$
0.60	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$ (lower mass)
0.36	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$ (higher mass)

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase

ambiguity is resolved by choosing a negative sign for the $\Delta(1620)$ S_{31} coupling to $\Delta(1232)\pi$.

$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow \Delta(1232)\pi$, D-wave	$(\Gamma_1 \Gamma_4)^{1/2} / \Gamma$		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
-0.36 to -0.28 OUR ESTIMATE			
-0.24 ± 0.03 -0.33 ± 0.06 -0.39 -0.40	MANLEY 92 BARNHAM 80 2,6 LONGACRE 77 3 LONGACRE 75	IPWA IPWA IPWA IPWA	$\pi N \rightarrow \pi N & N\pi\pi$ $\pi N \rightarrow N\pi\pi$ $\pi N \rightarrow N\pi\pi$ $\pi N \rightarrow N\pi\pi$
$\Gamma(\Delta(1232)\pi, D\text{-wave}) / \Gamma_{\text{total}}$	Γ_4 / Γ		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.39 ± 0.02	VRANA 00	DPWA	Multichannel
$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N\rho$, $S=1/2$, S-wave	$(\Gamma_1 \Gamma_6)^{1/2} / \Gamma$		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
+0.12 to +0.22 OUR ESTIMATE			
+0.15 ± 0.02 +0.40 ± 0.10 +0.08 +0.28	MANLEY 92 BARNHAM 80 2,6 LONGACRE 77 3 LONGACRE 75	IPWA IPWA IPWA IPWA	$\pi N \rightarrow \pi N & N\pi\pi$ $\pi N \rightarrow N\pi\pi$ $\pi N \rightarrow N\pi\pi$ $\pi N \rightarrow N\pi\pi$
$\Gamma(N\rho, S=1/2, S\text{-wave}) / \Gamma_{\text{total}}$	Γ_6 / Γ		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.14 ± 0.03	VRANA 00	DPWA	Multichannel
$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N\rho$, $S=3/2$, D-wave	$(\Gamma_1 \Gamma_7)^{1/2} / \Gamma$		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
-0.15 to -0.03 OUR ESTIMATE			
-0.06 ± 0.02 -0.13	MANLEY 92 2,6 LONGACRE 77	IPWA IPWA	$\pi N \rightarrow \pi N & N\pi\pi$ $\pi N \rightarrow N\pi\pi$
$\Gamma(N\rho, S=3/2, D\text{-wave}) / \Gamma_{\text{total}}$	Γ_7 / Γ		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.02 ± 0.01	VRANA 00	DPWA	Multichannel
$(\Gamma_i \Gamma_f)^{1/2} / \Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N(1440)\pi$	$(\Gamma_1 \Gamma_8)^{1/2} / \Gamma$		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.11 ± 0.05	BARNHAM 80	IPWA	$\pi N \rightarrow N\pi\pi$
$\Gamma(N(1440)\pi) / \Gamma_{\text{total}}$	Γ_8 / Γ		
<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.00 ± 0.01	VRANA 00	DPWA	Multichannel

$\Delta(1620)$ PHOTON DECAY AMPLITUDES

$\Delta(1620) \rightarrow N\gamma$, helicity-1/2 amplitude $A_{1/2}$

VALUE ($\text{GeV}^{-1/2}$)	DOCUMENT ID	TECN	COMMENT
+0.027±0.011 OUR ESTIMATE			
0.035±0.020	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$
0.035±0.010	CRAWFORD 83	IPWA	$\gamma N \rightarrow \pi N$
0.010±0.015	AWAJI 81	DPWA	$\gamma N \rightarrow \pi N$
-0.022±0.007	ARAI 80	DPWA	$\gamma N \rightarrow \pi N$ (fit 1)
-0.026±0.008	ARAI 80	DPWA	$\gamma N \rightarrow \pi N$ (fit 2)
0.021±0.020	CRAWFORD 80	DPWA	$\gamma N \rightarrow \pi N$
0.126±0.021	TAKEDA 80	DPWA	$\gamma N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
-0.050	PENNER 02D	DPWA	Multichannel
0.042±0.003	LI 93	IPWA	$\gamma N \rightarrow \pi N$
0.066	WADA 84	DPWA	Compton scattering
-0.005±0.016	FELLER 76	DPWA	$\gamma N \rightarrow \pi N$

$\Delta(1620)$ FOOTNOTES

¹ CHEW 80 reports two S_{31} resonances at somewhat higher masses than other analyses. Problems with this analysis are discussed in section 2.1.11 of HOEHLER 83.

² LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

³ From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

⁴ See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

⁵ LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

⁶ LONGACRE 77 considers this coupling to be well determined.

$\Delta(1620)$ REFERENCES

For early references, see Physics Letters **111B** 1 (1982).

ARNDT 06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
PDG 06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
ARNDT 04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)
PENNER 02C	PR C66 055211	G. Penner, U. Mosel	(GIES)
PENNER 02D	PR C66 055212	G. Penner, U. Mosel	(GIES)
VRANA 00	PRPL 328 181	T.P. Vrana, S.A. Dytman,, T.-S.H. Lee	(PITT+)
ARNDT 96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)
ARNDT 95	PR C52 2120	R.A. Arndt <i>et al.</i>	(VPI, BRCO)
HOEHLER 93	πN Newsletter 9 1	G. Hohler	(KARL)
LI 93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)
MANLEY 92	PR D45 4002	D.M. Manley, E.M. Saleski	(KENT) IJP
Also Also	PR D30 904	D.M. Manley <i>et al.</i>	(VPI)
ARNDT 91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP
WADA 84	NP B247 313	Y. Wada <i>et al.</i>	(INUS)
CRAWFORD 83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)

HOEHLER	83	Landolt-Bornstein 1/9B2	G. Hohler	(KARLT)
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)
ARAI	80	Toronto Conf. 93	I. Arai	(INUS)
Also		NP B194 251	I. Arai, H. Fujii	(INUS)
BARNHAM	80	NP B168 243	K.W.J. Barnham <i>et al.</i>	(LOIC)
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP
CRAWFORD	80	Toronto Conf. 107	R.L. Crawford	(GLAS)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
TAKEDA	80	NP B168 17	H. Takeda <i>et al.</i>	(TOKY, INUS)
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP
FELLER	76	NP B104 219	P. Feller <i>et al.</i>	(NAGO, OSAK) IJP
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP